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The development of the sexual organs and sporogonium of Marchantia polymorpha*

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(WITH PLATES 21–25)

For some time past the writer has been preparing sets of slides for the use of students in a course in embryology. The aim has been to get together series as complete as possible to illustrate the important steps in the development of at least one representative of each of the great groups of green plants. The slides when finished are numbered, and each valuable section on the slide is marked and numbered. The stages represented are then carefully arranged in sequence and outlines prepared in which they are indicated in their proper order with the numbers of the slides and sections in which they appear. In this way the student, having had all the sections found, marked, and arranged for him, and having to waste no time in searching for the desired stages, can study the maximum amount of material in the minimum of time.

It should be emphasized that such slides are not intended to take the place of but to supplement those which the student makes for himself in order to get training in the methods used in the preparation of such material. It will be readily understood that to get together series of this kind requires much time and patience, but the writer feels that the outlay is fully justified by the results obtained. The student who goes over a set of preparations such as is illustrated in the present paper, making drawings of all the stages, and finally writing up for himself an account of the development of the plant based on his own studies and drawings has at

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the end a feeling of satisfaction in having acquired a fairly comprehensive knowledge of the embryology of that species and of the group to which it belongs. Moreover, the preparation of such sets may prove to be of almost as much value to the teacher as to the student.

As the representative of the Marchantiaceae the writer naturally selected *Marchantia polymorpha*, it being the most accessible as well as the most easily studied member of the group. An examination of what has been written concerning this species brought out a rather surprising state of affairs. *Marchantia polymorpha* has long been a favorite object for class study. It has been described and illustrated in practically every textbook treating of the liverworts, and has been made the subject of numerous investigations, so that it would seem as if nothing remained to be done with it. Yet nowhere has there ever been published an even approximately complete account of the development of the antheridia, archegonia, and sporogonia of this species, nor anything approaching a complete series of figures illustrating these phenomena.

Inasmuch as this plant is so commonly used in class work it has seemed to the writer to be desirable that a fairly complete series of illustrations should be available for the use of students. The accompanying figures with the brief account of the development of the sexual organs and sporogonium are therefore presented in the hope that they may be found useful.

Marchantia grows commonly on damp soil in ravines or along wood-roads, but reaches its best development on damp, burnt soil. The writer once visited a burnt-out swamp several acres in extent in which the ground was nearly completely covered with luxuriant thalli to a depth in some places of several inches. The gametophores begin to appear early in May, and the sporogonia mature in July.

ANTHERIDIUM

The antheridia of *Marchantia* are sunk in cavities in the upper surface of the antheridiophore. They develop in acropetal succession, the youngest being near the margin and the oldest near the center of the disk. They do not originate from all portions of the margin equally but the younger ones are produced in certain

definite meristematic regions which lie between the lobes. Goebel regards the antheridiophore as representing an entire branching system, which divides repeatedly, the apices being near the margin and constituting the meristematic regions mentioned. While young antheridia may be found on quite large receptacles, it is best to collect the smaller ones in which the stalk is still very short or even has not begun to elongate. The material from which the present study was made was collected May 26, 1900, and fixed in Flemming's solution. The sections are 8–10 μ thick and stained in Delafield's hematoxylin. This stain is well adapted to work of this kind since it brings out the cell-walls and nuclei very clearly.

The youngest antheridium that I have been able to recognize definitely as such is shown in *figure 1*. It is a conical cell several cells removed from the margin, and has evidently been cut off by a transverse wall from the cell beneath it. A study of the section shows that the neighboring cells also have been derived in the same manner from the cells beneath. An examination of many preparations of young stages has convinced me that the antheridial rudiment of *Marchantia* at no time projects above its fellows later to become buried, but is one of the superficial, dorsal, submarginal cells of the receptacle, having the same origin and being cut off at practically the same time as the cells adjacent to it, but soon becoming separated from them, assuming a conical form, and becoming richer in protoplasmic contents. The one shown in *figure 1* has already been slightly surpassed by the elongating adjacent cells.

In the stage shown in *figures 2* and *3*, the rudiment has been divided by a transverse wall into two cells, the proximal being the mother-cell of the stalk, while the distal is the mother-cell of the antheridium proper. Occasionally the receptacle is so convex above that the young antheridia are nearly horizontal so that transections of the gametophore give longisections of the young organ (*figs. 4–6*).

The young antheridium now enlarges (*figs. 4, 5*) and soon becomes sunk in a cavity owing to the division and upward growth of the surrounding cells (*fig. 6*). The divisions in the lower cell to form the stalk follow no regular order but may be either longi-

tudinal or transverse or both, as may be seen by inspection of *figures 9–24*. In the distal or antheridial cell, however, the divisions are regular. It soon segments transversely into either two (*figs. 7–12*), or three (*figs. 13–20*), or perhaps rarely four cells (*cf. figs. 21, 23*). I have not seen more than two transverse walls in any antheridium at this age, a greater number of walls, so far as my observation goes, always appearing in organs which have progressed considerably in their development, so that they were probably formed subsequently to vertical division (*cf. figs. 24, 25*). Each cell of the antheridium now soon divides by a vertical wall into two. This division usually appears first in the proximal cells (*figs. 10, 14–18*), but occasionally the distal one divides first (*figs. 11, 12*). These vertical walls are then followed by others at right angles to them in each cell so that the young organ consists of two or three tiers of four cells each. In each cell of each tier now appears a periclinal wall separating it into an inner spermatogenous cell and a peripheral wall-cell. This periclinal division begins at the base of the antheridium and progresses toward the apex (*figs. 19–23*), so that the interior spermatogenous cells are finally completely enclosed by the enveloping wall. Further divisions in the latter are entirely radial, so that it remains a single layer of cells in thickness.

The young antheridium now increases rapidly in size. The stalk divides transversely and vertically so that it ultimately consists of 5 or 6 tiers of about four cells each (*figs. 26–29*). The cells of the interior divide transversely (*figs. 24, 25*) and vertically (*figs. 26–29*), so that groups of cuboidal cells result. The original division-walls remain evident even in the mature structure. *Figure 29* represents an antheridium about one fourth to one third grown. The mature organ is similar in form but is much larger and contains a much greater number of cuboidal cells, formed by repeated division of the inner cells. A group of such cells from a fully grown antheridium is shown in *figure 30*. The next division in each cuboidal cell is diagonal, so that two triangular cells or spermatids result (*fig. 31*). According to Ikeno ('03) and Campbell ('05), this final diagonal division is unaccompanied by a wall in *Marchantia* and *Fimbriaria*. My own preparations stained with Delafield's hematoxylin, which brings out cell-walls clearly, shows

diagonal walls very distinctly in some of the cells, but not in all, so that they seem to disappear soon after being formed. The nuclear phenomena accompanying the production of the spermatids and their transformation into spermatozoids, together with the changes in the blepharoplast and the development of the cilia have not been specially studied, since they have been so recently worked out by Ikeno ('03).

The writer has not yet observed the explosive discharge of the spermatozoids, which is so easily seen in *Conocephalum* when the moisture conditions are right. The same phenomenon probably occurs also in *Marchantia*, and one can easily see how it might be useful in effecting fertilization in those archegonia which are matured after the elongation of the stalk of the gametophore.

ARCHEGONIUM

In the vicinity of Ithaca, the young archegoniophores begin to appear early in May. Archegonia mature and fertilization usually takes place by the time the stalk begins to elongate. The necks of such mature organs are strongly curved outward toward the margin of the receptacle. If the first-formed archegonia are fertilized, few are produced subsequently, but if fertilization is not effected they continue to develop in numbers even after the stalk is somewhat elongated. The necks of the later-formed organs are nearly straight. *Figures 32* to *69* were made from material collected when the stalks of the archegoniophores had just begun to elongate, and when mature antheridia were present on adjacent plants. It was gathered May 9, 1907, and fixed in Gilson's solution. The sections are 8–10 μ thick and stained in Delafield's hematoxylin.

The archegonia arise in radiating rows from the tissue between the lobes on the underside of the gametophore. The youngest are nearest the stalk and the oldest near the margin. The development accords in general with that usual in the Marchantiales, but since it differs in some particulars it seems best to give a brief account of the whole process. A superficial cell pushes outward beyond its fellows and its distal part is cut off by a transverse wall. The hemispherical cell thus formed is the mother-cell of the archegonium (*figs. 32, 33, 40*), and may be recognized by its deeply

staining contents. I cannot confirm the statement of Strasburger ('69) that this mother-cell is divided into two by a transverse wall, but the first division-wall is obliquely vertical and curved, and divides the mother-cell into two unequal cells (*figs. 34, 35, 63*). The second wall is in the larger cell, and is likewise obliquely vertical and curved (*figs. 36, 37*), cutting both the first division-wall and the wall of the mother-cell (*fig. 38*). A third similar wall cuts both the first and second (*cf. fig. 46*). The young archegonium has thus been segmented into an axial cell, triangular in transection, bounded by three peripheral ones. The axial cell is next divided by a transverse wall into a distal cover-cell and a proximal mother-cell of the axial row (*figs. 39, 40*). The cover-cell may segment at once (*fig. 41*), but more often it remains entire for some time (*cf. figs. 42–65*). Ultimately it becomes divided into four by two walls at right angles to each other (*figs. 47, 67, 57, et seq.*). Each of the three peripheral cells next divides by a transverse wall near the middle (*figs. 42, 43*), and these are soon followed by a corresponding one in the axial cell dividing it into a proximal central cell and a distal neck-canal mother-cell (*figs. 44, 45*). These last divisions have separated the young archegonium into two regions: the neck and the venter. About the same time each of the three peripheral wall-cells divides radially so that the wall consists of six rows of cells (*fig. 46*). Although the wall of the venter undergoes further radial division (*fig. 59*), six remains the constant number in the neck (*figs. 60, 66*).

Meanwhile the cell or cells immediately beneath the archegonium, from which the mother-cell was originally derived, grow outward (*figs. 37, 39, 40*), and divide transversely, forming what at first appears to be a stalk of the archegonium (*figs. 43–45*), but what really becomes the proximal cells of the wall of the venter (*cf. figs. 48–65*). In the young archegonium shown in *figure 34* this has taken place unusually early. It will thus be seen that the archegonium is not entirely derived from the original hemispherical mother-cell.

The young archegonium now undergoes a period of growth. The axial cells elongate, the central cell becoming the larger with a conspicuous nucleus. The wall-cells undergo repeated trans-

verse division, and those of the venter radial division also (*figs. 48–54*). The neck-canal mother-cell now divides transversely into two (*figs. 55, 56*), and then each of these into two, making four neck-canal-cells (*fig. 58*). The central cell then divides unequally into a distal ventral canal-cell and the larger egg. The writer does not think that a definite cell-wall is laid down in this last division. If it is, it disappears very soon, for the two cells are separated by a space in almost every instance (*fig. 61*). As a rule the central cell does not divide until after the four neck-canal-cells have been formed, but quite a number of instances were noted in which it had segmented when only two canal-cells were present (*fig. 57*).

All the parts of the archegonium having been differentiated, further development is in the nature of expansion or enlargement of the parts already formed. Up to this time the organ has been nearly cylindrical, but after the division of the central cell the venter becomes somewhat swollen or thickened owing to the enlargement of the egg within (*figs. 62–65, 68, 69*). The cytoplasm stains very intensely and the nucleus is large and conspicuous. The neck elongates by repeated transverse division of the wall-cells, and sometimes becomes very long and curved. The neck-canal-cells elongate and the separating walls soon disappear (*figs. 65, 68*). While four is the usual number of cells, their nuclei occasionally divide so that six or seven sometimes appear (*figs. 65, 68*). In one case (*fig. 68*) the cytoplasm of one of the cells had segmented so that five distinct masses were present. As the archegonium approaches maturity, the ventral canal-cell and the neck-canal-cells become disorganized and coalesce into a slender mucilaginous strand in the cavity of the neck. Soon the cover-cells break apart and the mass exudes, leaving an open channel to the egg (*fig. 69*). The latter becomes nearly spherical and stains very deeply. No indication of a "receptive spot" was observed.

EMBRYO AND SPOROGONIUM

The sporogonia of *Marchantia* develop rapidly. Archegonia are ready for fertilization in May and fully mature sporogonia may be found in the latter part of June or in July. Part of the material collected for archegonia May 9, 1907, was kept in the laboratory

under a bell-jar for five days, when it was fixed in chrome-acetic solution. *Figures 70–90* were made from this collection. *Figures 91–101* are from plants killed in Flemming's solution June 9, 1900. The sections are 8–10–12 μ thick and stained in Delafield's hematoxylin.

The unfertilized egg of *Marchantia* is nearly spherical in form, and is stained intensely by Delafield's hematoxylin. After fertilization it elongates slightly, becomes surrounded by a wall, and is stained with difficulty and diffusely with the same reagent (*figs. 70, 71*). This difference in staining capacity is marked and continues until the embryo has become many-celled (*fig. 93*). Another conspicuous reaction to stain is shown by the inner surface of the wall of the archegonium, which becomes deeply colored, so that in sections the pale embryo stands out in bold relief against the dark background (*figs. 70, 76, 81, 82, et al.*) The first division-wall in the fertilized egg is obliquely transverse. *Figures 72–76* show longitudinal sections of five embryos at this stage. These and the subsequent figures have been arranged so that the axes of the archegonia are parallel. In *figure 75* the wall is transverse, while extremes of obliquity are shown in more advanced embryos in *figures 77* and *84*. The second wall is perpendicular to the first, dividing the embryo into quadrants (*figs. 77–81*). The third (*fig. 82*), at right angles to the first and second, divides it into octants.

The next divisions are anticlinal (*figs. 83–90*), and are placed at such a peculiar angle with the second and third walls that essentially similar patterns are presented in both longitudinal and transverse sections. This is made evident by comparing *figures 80–88* with *89* and *90*. As a rule anticlinal division has not proceeded far before periclinal walls begin to be laid down (*figs. 83, 85–87*). Further divisions are anticlinal, periclinal, and radial, without definite sequence, until a subspherical ball of cells is produced (*figs. 91–93*), in which the primary division-walls may usually be clearly recognized. Up to this time the embryo has increased but little in size, so that its component cells become successively smaller as division progresses (*cf. figs. 70–93*).

While the above-mentioned development is proceeding in the embryo, other and more conspicuous changes are taking place in the venter of the archegonium and in the tissue at its base. In

the first place the collar at the base of the archegonium, which is inconspicuous before fertilization (*figs. 63, 69*), by transverse division of its cells grows rapidly outward until it forms a tubular sheath, the pseudoperianth, surrounding the venter, and ultimately projecting far beyond it. This is always a single layer in thickness (*figs. 70, 76, 88, 92, 94*). In the second place, periclinal division begins in the wall of the venter, and continues until two or three layers of cells are formed at the sides of and above the embryo. The tissue thus formed is the calyptra, which serves as a protective covering for the growing embryo (*figs. 70, 71, 76, 81, 82, 88–90, 92, 94–98*). The contents of its cells soon become richer so that it is stained more deeply.

The third series of changes is in the base of the venter and in the cells immediately beneath it, from which the pseudoperianth arises (*fig. 70*). Division takes place in all directions so that the base, originally narrow and rarely more than three cells across, becomes broad and massive (*figs. 70, 76, 88, 92, 94*). The cells thus formed from the base of the archegonium are generally smaller than those of the adjacent gametophore (*fig. 94*), and soon become rich in protoplasmic content and stain deeply.

The embryo and surrounding tissues now enlarge rapidly and the contents of all the cells increase in staining capacity (*fig. 94*). This is especially noticeable in the tissue beneath the embryo, derived from the base of the archegonium. The embryo itself becomes nearly spherical (*figs. 94–97*), and then broader than long (*figs. 98, 99*). The first indication of its differentiation into parts is a change in the staining capacity of the cells. Those in the distal half become richer in protoplasmic content, and form the capsule, while those of the proximal half stain with less avidity, and give rise to the stalk and foot (*figs. 95, 96*). An inspection of the embryo shown in *figure 95* shows that the stalk and capsular halves are separated by the first transverse division-wall, and this is usually the case. That it is not always true, however, is shown in *figure 96*. In this embryo the original walls were decidedly oblique, as in *figures 77* and *84*. In such cases the first division-wall does not separate the embryo into the stalk and capsular halves, but this differentiation is determined by other influences. In general it is true that, whatever be the direction of the

first division-wall, the proximal cells constituting about one half of the embryo give rise to the stalk and foot, while those of the distal half become the capsule. The line of demarcation between them is not always clear-cut, and generally coincides very nearly with the first transverse wall; but often it does not so coincide, and certainly does not necessarily do so.

As the young sporogonium enlarges, the superficial cells of the capsular portion stain less deeply and become sharply set off as an outer sterile wall of a single layer of cells enclosing the deeply staining sporogenous tissue within (*fig. 97*). The cells of the latter at this time are irregularly isodiametric, and similar to those of the stalk half. In the sporogonium figured one can detect a slight bulging of the proximal tissue of the stalk to form the beginning of the foot.

A more advanced and very interesting stage is shown in *figure 98*. The whole structure has become broader; the wall is sharply differentiated from the sporogenous tissue within; the cells of the latter have increased in number, and most of them have elongated somewhat in a direction parallel to the axis of the archegonium; the proximal cells of the stalk have become richer in contents, and are closely applied to the tissue at the base of the archegonium, into which they have begun to penetrate to form the foot. It should be noted that the cells of the archegonium adjacent to the foot are not crushed out nor flattened, but are plump and the contents stain deeply.

A still more advanced condition is shown in *figure 99*. The foot has penetrated more deeply into the basal cells of the archegonium, and has expanded laterally, forming a "pileus-shaped" absorbent organ, the cells of which are filled with deeply staining food material in the form of elliptical bodies. The capsular portion is broad, the sporogenous cells numerous and plainly elongated. In neither of the sporogonia shown in *figures 98* and *99* is the line of demarcation between the stalk and sporogenous tissue regular, so that it probably does not exactly conform to the original transverse wall of the embryo.

In the still older sporogonium shown in *figure 100*, the foot has become more massive and has penetrated more deeply into the tissue of the base of the archegonium. The cells of the sporog-

enous tissue have separated completely from one another, and have elongated. The great majority are narrowly triangular in outline, and are frequently arranged in pairs end to end. A few, however, are narrow and slender, and present the first indications of a differentiation between sporogenous cells and elaters. In the much larger embryo shown in *figure 101*, the distinction between fertile cells and elaters is more marked. The former have lost to some extent the regular triangular outline, while the latter are much more slender and sometimes flexuous. The two kinds of cells alternate irregularly.

In its further development the sporogonium elongates rapidly until it becomes oblong or elliptical in general outline. The stalk, however, remains for a long time very slight. At the same time the separate cells filling the capsule increase in size. The elaters become long and fusiform, and the contents arranged in a spiral manner next the wall. While the sporogenous cells increase in size they do not seem to increase in number after the separation shown in *figure 100*. They soon divide, however, by transverse, or by transverse and longitudinal walls into groups of eight, rarely four, cells (*fig. 102 a–h*), which do not separate but remain connected together. These are the spore-mother-cells. If the division is transverse only, the mother-cells are arranged in rows (*fig. 102 a, d, e*). If longitudinal division also occurs, the mother-cells are biseriate or subbiseriate in the group (*b, c, f, g, h*). A very characteristic condition is shown in figures *c* and *h*, in which the original cells were subtriangular in outline and arranged in pairs, as appears so often in *figures 100* and *101*. The resulting groups of mother-cells are also subtriangular in form and still remain in pairs. The mother-cells are irregular in shape, and are flattened where contiguous ones come in contact.

The mother-cells now increase in size as the capsule expands. The details of their division have not yet been worked out, but each gives rise to four tetrahedral spores (*fig. 103 i–m*). The spores remain connected in the tetrads for a long time, and the latter, as well, cling together nearly as long in their original groups. The tetrads, however, seem to become free from one another before the spores separate (*fig. 103 m*).

About the time of the division of the spore-mother-cells, ac-

tivity begins in the stalk. Each component cell divides repeatedly in a direction transverse to the long axis of the sporogonium, so that very regular rows of cells are produced between the foot and the capsule. The latter is thus pushed outward until the calyptra is ruptured at its apex. At first the cells of the stalk are broader than long, but later they increase greatly in length so that the stalk elongates, pushing the capsule beyond the surrounding perianth. As the capsule dries it ruptures at the apex into numerous lobes so that the spores and elaters are set free.

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Explanation of figures (plates 21-25)

All figures were drawn with the aid of the camera lucida. Figures 1–30, 32–69, 102, and 103, were drawn with the B. & L. one-eighth objective and one-inch ocular. Figure 31 was drawn with the one-twelfth objective and one-inch ocular. Figures 70–101 were drawn with the one-sixth objective and one-inch ocular. The exact magnification is indicated with each plate.

ANTHERIDIUM

FIG. 1. Longitudinal section of gametophore showing 1-celled rudiment of the antheridium.

FIGS. 2, 3. The antheridial rudiment has divided by a transverse wall into the mother-cell of the stalk and mother-cell of the antheridium proper.

FIGS. 4, 5. Same as last but from transverse section of the gametophore; antheridium enlarging.

FIG. 6. Same as last but young antheridium becoming more deeply buried by the upgrowth of the surrounding cells.

FIGS. 7, 8. The whole organ more deeply buried; antheridial mother-cell divided by a transverse wall.

FIG. 9. As in last but division beginning in mother-cell of the stalk.

FIGS. 10–12. As in last but vertical division beginning in mother-cell of antheridium proper.

FIG. 13. Antheridial mother-cell divided by two transverse walls.

FIGS. 14–18. As in last but showing variations in division in the stalk, and successive steps in vertical division of antheridium.

FIGS. 19–23. Steps in the periclinal division of the antheridium to separate the wall from the spermatogenous tissue within.

FIGS. 24, 25. Antheridium enlarging; beginning radial division in the wall, and transverse division of spermatogenous tissue.

FIGS. 26–28. Further radial division in the wall; successive steps in division of spermatogenous tissue by transverse and vertical walls into cuboidal cells; increasing massiveness of the stalk.

FIG. 29. Antheridium one fourth to one third grown; original vertical and transverse walls plainly evident.

FIG. 30. A block of cuboidal cells from a mature antheridium just before their diagonal division to form the spermatids.

FIG. 31. A block of cuboidal cells from same antheridium as figure 30, showing diagonal division to form the spermatids. Note that in some of the cells diagonal walls appear between the spermatids. One-twelfth objective.

ARCHEGONIUM

FIGS. 32, 33, 40. Mother-cell of the archegonium cut off from the cell of the gametophore from which it has arisen.

FIGS. 34, 35. The mother-cell divided by one obliquely vertical wall.

FIGS. 36, 37. The mother-cell divided by two obliquely vertical walls.

FIG. 38. Transection of young archegonium, showing relation of the two walls.

FIGS. 39, 40. The axial cell divided by a transverse wall to form the cover- and the mother-cell of the axial row.

FIG. 41. Cover-cell divided.

FIG. 42. One peripheral cell divided transversely.

FIG. 43. All peripherals divided transversely.

FIGS. 44, 45. Peripherals and mother-cell of axial row divided transversely, the latter into the central cell and mother-cell of the neck-canal-cells. The young archegonium is now differentiated into the neck and venter.

FIG. 46. Transection of venter at this stage.

FIG. 47. Transection of cover of same archegonium as in figure 46.

FIGS. 48–54. Steps in the radial division of the wall and increase in length of the archegonium.

FIGS. 55, 56. The neck-canal mother-cell has divided transversely into two.

FIG. 57. An abnormal condition in which the ventral canal-cell has been cut off before the formation of four neck-canal-cells.

FIG. 58. Four neck-canal-cells, central cell undivided.

FIG. 59. Transection of venter of about the stage of figure 58.

FIG. 60. Transection of neck of same archegonium.

FIG. 61. Central cell divided into the egg and ventral canal-cell.

FIGS. 62–64. Archegonium enlarging; four neck-canal-cells.

FIG. 65. Nuclei of two of the neck-canal-cells divided.

FIG. 66. Transection of neck of about the stage of figure 65.

FIG. 67. Transection of cover-cells of same archegonium as in figure 66.

FIG. 68. Archegonium mature; canal-cells ready to disintegrate; five neck-canal-cells with seven nuclei.

FIG. 69. Base of archegonium, egg ready for fertilization.

SPOROGONIUM

FIG. 70. Base of an archegonium containing a fertilized but undivided egg. Note the beginning pseudoperianth.

FIG. 71. Transection of similar stage.

FIGS. 72–76. Fertilized egg once divided. In 76 note the growth of the pseudoperianth and increasing tissue at base of archegonium.

FIGS. 77–80. Embryo divided into quadrants.

FIG. 81. Transection of quadrant stage.

FIG. 82. Transection of octant stage. In 81 and 82 note the periclinal division in the wall of the venter.

FIGS. 83–88. Steps showing formation of anticlinal walls in each octant. Figures 83, 85–87, show also the beginning of periclinal walls. In 88 note the increasing pseudoperianth and tissue at base of the archegonium.

FIGS. 89, 90. Transections of similar stages.

FIGS. 91–93. Older embryos. Note the slight increase in size over 70.

FIG. 94. Embryo increasing in size. Note the massive base of the archegonium and the pseudoperianth.

FIG. 95. An older stage. Note that the distal half stains more deeply, the two halves being separated by the original transverse wall.

FIG. 96. Similar to last but the distal deeply staining portion is not separated from the proximal paler part by the original transverse wall.

FIG. 97. An older larger stage in which the distal half of the embryo is differentiated into an outer wall of one layer of cells enclosing the deeply staining sporogenous tissue within, and the basal portion of the proximal half has begun to grow toward the tissue at the base of the archegonium to form the foot.

FIG. 98. The deeply staining foot has begun to penetrate the base of the archegonium, and the cells of the sporogenous tissue have begun to elongate somewhat.

FIG. 99. Sporogenous cells about as in figure 98, but the foot has pressed into the base of the archegonium and expanded to form a pileus-shaped absorbent organ, which is filled with food material.

FIG. 100. A more advanced stage in which the sporogenous cells have separated from one another and become long-triangular in shape and often arranged in pairs.

FIG. 101. Somewhat older than the last. The sporogenous cells have become differentiated into two kinds: stout ones and more slender elaters.

FIG. 102. The stout cells of the last figure have become divided into 8 (rarely 4) spore-mother-cells, those of each group being arranged either in single rows (*a*, *d*, *e*) or in a triangular or subbiseriate manner (*b*, *c*, *f*, *g*, *h*). The groups are frequently arranged in pairs (*b*, *c*, *h*) corresponding to the paired cells of figures 100 and 101.

FIG. 103. An older stage in which each spore-mother-cell has divided into four spores, the tetrads still clinging together in groups of 4 or 8. In *m*, the oldest stage, they have begun to separate but still form an easily recognized group.

Studies of West Indian plants — I

NATHANIEL LORD BRITTON

1. THE JAMAICAN SPECIES OF HERNANDIA

On March 20, 1908, while exploring a wooded hill near Dolphin Head Mountain, parish of Hanover, in the western part of Jamaica, in company with Mr. William Harris, we observed large trees which were unknown to us from the character of their trunks, and too high to enable us to determine the character of their foliage without a pair of field glasses, which we did not have along that day. While sitting at lunch in a relatively open place in the forest, we observed the top of one of these trees, some 30 meters high and at least a meter in diameter, against the sky line, and saw that it was covered with round fruits, some of which we found on the ground under this tree, and realized that we had found a very interesting species. Our negro guide felled a somewhat smaller tree with his machete, and thus enabled us to obtain excellent fruiting herbarium and museum specimens of the Jamaican species of *Hernandia*.

Up to this time the tree does not appear to have been definitely known to botanists in the island of Jamaica. Patrick Browne (Civil and Natural History of Jamaica, 373, 1756), admits the genus and remarks: "This tree is pretty common in Barbadoes and Mountserat, and grows to a considerable size in those islands; but I have not seen any in Jamaica, though I have been credibly informed that it was frequent in the parish of Portland. The cups that sustain and partly invelop the nuts are very large, and, as they move in the wind, keep a whistling noise, which is often frightful to unwary travellers. The seeds are very oily." Browne cites Jack-in-a-Box as a common name.

In Flora of the British West Indian Islands, page 285, published in 1860, Grisebach does not attribute the tree to Jamaica at all, thus indicating that no specimens of it were extant at that time, but Meissner, in DeCandolle's Prodromus (**15**[1] : 263. 1864),

does credit it to Jamaica, and cites P. Browne, although, as he omits an exclamation mark, it is evident that he did not see a specimen, nor does his herbarium, now at the New York Botanical Garden, contain any *Hernandia* from Jamaica; Meissner refers the record of P. Browne to the species *Hernandia sonora* L., native of the Windward Islands and Porto Rico, and perhaps also of the East Indies.

Hernandia sonora is readily distinguishable from the other species by its peltate, long-pointed leaves, and the only other West Indian species known is the Cuban *Hernandia cubensis* Griseb., which has narrow long-acuminate leaves. Under *H. sonora*, Meissner (DC. Prodr. 264) notes a variety *guadeloupensis* from Guadeloupe Island, which has leaves rounded at the apex and base, or slightly cordate. It is possible but not probable that this is the same as the Jamaican tree, but the description is insufficient to make this certain. In any event, the Jamaican tree is evidently specifically distinct from either *H. sonora*, or *H. cubensis*. There is a species of *Hernandia*, *H. guianensis*, in French Guiana, but not much is known of it other than the plate of Aublet, Pl. Guian. *pl. 329*, which shows that this must be quite different from the plant here to be described.

Hernandia jamaicensis Britton & Harris

A tree 30 m. high or less, with spreading and ascending stout branches, the trunk becoming at least a meter in diameter, the young twigs more or less flattened and angled. Leaves subcoriaceous, sometimes 2.5 dm. long; petioles stout, somewhat shorter than the blade, but sometimes 1 dm. in length, the blades elliptic to elliptic-obovate, obtuse at the apex, obtuse or subcuneate at the base, 3-nerved or faintly 5-nerved, not at all peltate; inflorescence as long as the leaves or longer, racemose or racemose-paniculate; calyx of the pistillate flowers turbinate, about 5 mm. long, its margin truncate; fruiting calyx subglobose, yellow, fleshy, 3–4 cm. long and about as thick as long, its wall about 1 mm. thick, its orifice 1.5–2 cm. wide with a slightly raised margin; drupe ovoid, nearly 2 cm. long, 1.5 cm. in diameter, rounded at the base, bluntly pointed, bluntly 8-ribbed and rugose between the ribs.

On wooded hill, at about 400 meters altitude, near Dolphin Head, Jamaica (*Britton 2321*, type; *Harris 10312*); Woodstock, Westmoreland, Jamaica (*Harris 9835*).

2. THE GENUS CASSIPOUREA IN JAMAICA

Cassipourea was proposed by Aublet (Hist. Pl. Guian. **1**: 528) in 1775 for a tree of French Guiana, his *Cassipourea guianensis* being the type of the genus. Swartz (Prodr. 84) published the generic name *Legnotis*, including in it two species, *L. elliptica* from Jamaica and *L. Cassipourea*, based on Aublet's *Cassipourea guianensis;* he assigns no reason why his name thus published in 1788 should replace Aublet's *Cassipourea* of 1775. Poiret (Lam. Encycl. Suppl. **2**: 131) properly adopted the older generic name and transferred the *Legnotis elliptica* of Swartz to it. A number of additional species from tropical America and Africa have since been added by several authors, including *Cassipourea alba* Griseb. from the island of Dominica. That *Cassipourea* Aublet and *Legnotis* Swartz are the same genus seems evident from an examination of specimens.

Cassipourea elliptica (Sw.) Poir. is a shrub or small tree, sometimes reaching 6 meters in height, and grows in Jamaica on rocky wooded hillsides. Its elliptic long-pointed leaves are as brilliantly shining as those of any plant known to me, and individuals seen in contrast to the duller luster of other trees and shrubs stand out as most striking elements in the landscape. Mr. Harris, Dr. Hollick, and I, while botanizing near Kempshot, at an altitude of about 500 meters in the parish of St. James, western Jamaica, on March 23, 1908, had our first opportunity of studying this wonderfully beautiful plant in the field, and were fortunate enough to see its bright white flowers with strikingly laciniate petals, and it was an experience long to be remembered. The lustrous leaves and pediceled flowers distinguish *Cassipourea elliptica* from the two species to be described below. A remarkable feature of an individual tree found by us near Kempshot on March 24, 1908, is the development of the lower branches, which droop and bear leaves not more than one half the size of those on the flowering branches above, the twigs of these drooping branches being very slender and repeatedly forked. We preserved herbarium specimens of this curious bud-sport; if cuttings from such a branch could be propagated, they would doubtless yield a weeping *Cassipourea*.

The distinguishing characters of the three Jamaica species are indicated by the following key:

Pedicels as long as the calyx or longer; leaves brilliantly shining. 1. *C. elliptica.*
Pedicels much shorter than the calyx, or scarcely at all developed; leaves dull or faintly shining.
Leaves elliptic-lanceolate, narrowed at the base, the petioles about as long as the calyx. 2. *C. subsessilis.*
Leaves ovate, subcordate at the base, petioles only half as long as the calyx. 3. *C. subcordata.*

1. CASSIPOUREA ELLIPTICA (Sw.) Poiret

On rocky wooded hills, Kempshot and vicinity (*Britton 2397* and *2423; Harris 10330, 10340*); collected also in Jamaica by Swartz and by Purdie.

2. **Cassipourea subsessilis** sp. nov.

A tree about 6 m. high with slender spreading branches. Leaves elliptic-lanceolate, 6–9 cm. long, 3.5 cm. wide or less, acuminate at the apex, narrowed at the base, entire-margined, dull green on both sides, or faintly shining above, the midvein prominent beneath, the petioles 4–7 mm. long; flowers solitary in the axils, nearly or quite sessile; calyx campanulate, its tube 3 mm. long, its lobes ovate to ovate-lanceolate, about as long as the tube; ovary appressed-pubescent; capsule subfusiform, appressed-pubescent, about 1.3 mm. long, 2.5 mm. in diameter, surmounted by the persistent appressed-pubescent style.

On wooded hill near Dolphin Head, parish of Hanover, Jamaica, at about 400 meters altitude (*Britton 2316; Harris 10307*).

3. **Cassipourea subcordata** sp. nov.

A tree 4 m. high, the twigs rather stout, the branches ascending. Leaves ovate, bright green on both sides but not strongly shining, 5–7 cm. long, 3.5 cm. wide or less, short-acuminate at the apex, subcordate at the base, the midvein prominent beneath, the petioles rather stout, 2–3 mm. long; flowers 1 or 2 together in the axils, very nearly sessile; calyx tube obconic, 2.5 mm. long, the lobes ovate, obtusish, about as long as the tube, petals white, fimbriate.

Along a brook, Troy, Jamaica (*Britton 488*, type); collected also by Mr. Harris at the same place (*no. 9466*).

3. THE GENUS TEREBINTHUS P. BR. IN THE WEST INDIES

The type species of *Terebinthus* P. Br. is *Pistacia Simaruba* L., commonly known as the West Indian birch. A subsequent name for the genus is *Bursera* Jacq. but, as shown by Dr. J. N. Rose (Contr. U. S. Nat. Herb. **10**: 118), this name is unavailable, because *Terebinthus* has priority. Seven species are known to me from the West Indies, two of them here to be described as new; the Mexican species have been listed by Dr. Rose.

Leaflets broad, ovate, elliptic, or obovate.	
Leaflets 3–11, ovate, acuminate or acute.	
Leaflets thin; bark exfoliating in thin layers.	1. *T. Simaruba.*
Leaflets coriaceous; bark close.	2. *T. Hollickii.*
Leaflets only 1, obovate to elliptic, obtuse.	3. *T. simplicifolia.*
Leaflets narrow, oblong to lanceolate or oblanceolate.	
Leaflets obtuse at the base.	4. *T. glauca.*
Leaflets acute at the base.	
Inflorescence elongated, sometimes as long as the leaves.	
Leaflets 5–11, linear-oblong to linear-lanceolate.	5. *T. angustata.*
Leaflets 3–5, oblong to oblanceolate.	6. *T. inaguensis.*
Inflorescence short, compact, in fruit not longer than the petioles; leaflets 1–3.	7. *T. Nashii.*

1. TEREBINTHUS SIMARUBA (L.) W. F. Wight, Contr. U. S. Nat. Herb. **10**: 122. 1906.

Pistacia Simaruba L. Sp. Pl. 1026. 1753.
Bursera gummifera L. Sp. Pl. ed. 2, 471. 1762.
Bursera gummifera glabra Griseb. Fl. Br. W. I. 173. 1859.
Bursera gummifera pubescens Engler, in DC. Mon. Phan. **4**: 40. 1883.

Florida; Bahamas; Cuba; Jamaica; Haiti; Porto Rico; St. Thomas to Grenada; Mexico to Colombia and Venezuela.

Most of the Jamaica trees have pubescent twigs and leaf-rachises; this hairy race is evidently the typical one, based by Linnaeus on Sloane, *pl. 199*.

2. **Terebinthus Hollickii** sp. nov

A tree 6 m. high, with trunk 2.5 dm. in diameter, its bark about 8 mm. thick, reddish-gray outside, red inside, close, not peeling off in papery layers. Young twigs stout, pubescent; leaves 8–12

cm. long, clustered at the ends of the twigs; rachis pubescent with spreading hairs; leaflets 3–7, coriaceous, ovate 3–6 cm. long, 1.5–3 cm. wide, entire-margined, obliquely rounded at the base, short-acuminate at the apex, glabrous or very nearly so when old, very inconspicuously veined above, rather prominently veined beneath; petiolules stout, 3–5 mm. long; fruiting inflorescence 4–7 cm. long, the raceme simple or slightly compound, its axis pubescent; fruits 8–10 mm. long, about 7 mm. thick, bluntly triangular, on stout pedicels 4 or 5 mm. long; seed sharply 3-angled.

Dry rocky hillside, Fort Henderson, Kingston Harbor, Jamaica (*N. L. Britton & Arthur Hollick*, March 2, 1908, *no. 1816*).

3. **Terebinthus simplicifolia** (DC.)

Bursera simplicifolia DC. Prodr. **2**: 78. 1825.

Frequent on dry hillsides near the southern coast of Jamaica, becoming at least 13 meters high.

4. **Terebinthus glauca** (Griseb.)

Bursera glauca Griseb. Cat. Pl. Cuba 66. 1866.

Cuba.

5. **Terebinthus angustata** (Griseb.)

Bursera angustata Griseb. Cat. Pl. Cuba 65. 1866.

Cuba.

6. **Terebinthus inaguensis** (Britton)

Bursera inaguensis Britton, Bull. N. Y. Bot. Gard. **3**: 443. 1905.

Bahama Islands, from Eleuthera and Great Guana Cay to Inagua.

Combs 454, from Calicita, Santa Clara Province, Cuba, resembles this very closely, more closely than it does *T. angustata*.

7. **Terebinthus Nashii** sp. nov.

A tree about 3 m. high with nearly smooth terete twigs, glabrous throughout. Leaves 1–3-foliolate, the slender petiole 5–15 mm. long, somewhat glaucous; leaflets linear-oblong, narrowed at the base, obtuse or acutish and mucronulate at the apex, 3–5 cm. long, 1–1.5 cm. wide, pale green, very indistinctly veined on both sides, chartaceous; fruiting inflorescence short, few-fruited, 2 cm. long or less; fruits 6–7 mm. long, nearly as thick as long, borne on short stalks, 2–5 mm. long, the calyx persistent at their bases.

Gonaives to La Hotte Rochée on road to Terre Neuve (*Geo. V. Nash & Norman Taylor*, August 12, 1905, *no. 1559*).

4. PASSIFLORA CILIATA Ait.

This species was described in 1789 (Hort. Kew. 1 : 310) from plants cultivated by Mrs. Norman, who introduced it into England from Jamaica in that year. In the Botanical Magazine, plate 288, published January 1st, 1795, Curtis remarks that he saw it during the latter part of the preceding summer with great profusion of flowers in several collections, and the figure given by him at this place was made from a plant in the collection of Mr. Vere.

This beautiful passion-flower seems to have been much misunderstood by subsequent botanists. It appears to be confined naturally to the island of Jamaica, where Mrs. Britton found it in March, 1908, in quantities along roadsides through the hiils near Bulstrode, parish of Westmoreland, growing with *P. foetida*.

The plant has been supposed to be a variety of *P. foetida*, and has been so ranked by a number of authors. Grisebach, in Flora of the British West Indies, however, regarded it as specifically distinct, but apparently erred in attributing it to the Bahamas as well as to Jamaica. It has not been found in the Bahamas during any of our extensive explorations of that archipelago. So far as one can see, Grisebach was quite justified in maintaining it as a species distinct from *P. foetida*.

5. BIDENS PILOSA L.

This species was founded by Linnaeus (Sp. Pl. 832) in 1753 on the "*Bidens latifolia* hirsutior semine angustiore radiato" of Dillenius Hort. Eltham. 51. *pl. 43. f. 51*. The name has since been used by many authors for a very common and well-known tropical weed and often with the remark that it is not pilose. Dr. Gray surmised that the figure of Dillenius might really have been made from a plant of *B. frondosa*. During repeated trips to the West Indies I have looked closely at a great many individuals of this weedy plant but never could find any pilose ones until this spring; the species is usually almost or quite without trichomes. But at Moneague, Parish of St. Ann's, Jamaica, in April, 1908, I noticed

with great interest a roadside ditch full of these plants, some densely pilose all over, some essentially glabrous. I could not see at the time of collecting nor have I been able to see from further study of the dried specimens, any other difference whatever in the two races. Both are rayless, have identical achenes varying from 2 to 4, with awns relatively of the same length, leaves of the same shape and texture and involucral scales alike From the environment and occurrence there was nothing to prevent one coming from the seeds of the other. The plants as here observed are not as stout nor as large-leaved as the figure of Dillenius. The typical race of *Bidens pilosa* L. is then well named, but it is apparently rare.

Bidens leucantha (L.) Willd. published by Linnaeus as *Coreopsis leucantha* (Sp. Pl. ed. 2. 1282), also a very common tropical weed, has sometimes been regarded as a variety of *B. pilosa*. It has white rays often 1.5 cm. long, and in life appears very different, but herbarium specimens from which the rays have fallen are often difficult to place. It commonly grows with the glabrous *B. pilosa*, but perhaps more frequently in separate patches and in the West Indies one frequently sees large areas inhabited by the one to the exclusion of the other. At Kempshot, near Montego Bay, Jamaica, they grew together in a small garden and I was able to study them side by side; here *B. leucantha* had the involucral scales spreading at flowering time, while those of the glabrous *B. pilosa* were erect. I am inclined to regard *leucantha* as a distinct species. There is a race with undivided leaves.

6. THE GENUS MALACHE B. VOGEL.

Malache scabra was proposed by B. Vogel (Trew, Pl. Select. 50. *pl. 90.* 1772) as the name of a mangrove-swamp shrub common nearly throughout the West Indian region, subsequently called by Cavanilles (Diss. **3**: 136. *pl. 46. f. 1.* 1787) *Pavonia spicata*, and by Swartz (Fl. Ind. Occ. **2**: 1215. 1800) *Pavonia racemosa*. Trew cites pre-Linnaean names for the plant, and gives a detailed description and a beautiful illustration of it, especially referring to Sloane, Hist. Jam. 221. *pl. 139. f. 2;* Sloane's description and illustration are unmistakable for the species. Linnaeus does not appear to have had any name for it.

Pavonia Cav. has as its type species *P. spinifex* Cav. After studying quantities of this and of *Malache scabra*, both in the field and in the herbarium, I am confident that they should not be included in the same genus, inasmuch as they differ too widely in the floral and fruit-structure and in habit; only the most artificial classification can retain them as congeneric.

Malache scabra is a typical shrub of coastal swamps from Florida southward through the Caribbean region to Central America, Colombia, Trinidad, and Brazil, and is recorded as growing as far south as Peru on the western side of South America.

Having seen much of this species along mangrove swamps, nearly or quite always within the tidal influence at high water, I was surprised and interested while exploring the high rocky "Cockpit Country" of Jamaica with Mr. William Harris in September, 1907, to find a similar plant on hills in wet woods in the vicinity of Troy, reaching altitudes of at least 600 meters. Mr. Harris had collected fruiting specimens of it the year before, and had noticed its resemblance to the coastal shrub; Professor Urban has recently described it from these specimens (*Harris 9457*), as *Pavonia racemosa* var. *troyana* (Symb. Ant. **5**: 530. 1908). I obtained additional specimens both in flower and fruit in 1907 (*Britton 515*) and from field studies made then in comparison with *Malache scabra* I am convinced that this "Cockpit Country" plant is specifically distinct, and to be called **Malache troyana**; it has broader involucral bracts, much broader and differently shaped carpels, the anther-bearing part of the stamen-column proportionately shorter, and the fruiting peduncles are shorter and stouter. The plant is tall and slender and sometimes approaches the form of a small tree up to 4 or 5 meters high.

NEW YORK BOTANICAL GARDEN.

Some native weeds and their probable origin

ROLAND M. HARPER

Every botanist who attempts to classify the vegetation of a populous region, such as the northeastern United States, is confronted at the outset with the problem of distinguishing the natural or undisturbed habitats from those which have been modified by civilization. Of course all our vegetation has felt the influence of civilization more or less, but it seems possible to draw a fairly sharp line between those habitats whose flora is essentially the same now as it was in prehistoric times and those where it has been so much altered that it is impossible to reconstruct the primeval conditions.

In general it seems to be true — and the task of the phytogeographer would be almost hopeless if it were otherwise — that external influences of slight amount or of short duration produce no permanent changes in vegetation. As an example of the first kind, when the pine trees are removed from an area of southern pine-barrens the amount of sunlight reaching the ground is increased probably not more than 10 per cent., and this seems to make no perceptible difference to the herbaceous vegetation.* But if the ground is then plowed up and cultivated, the original vegetation disappears, most of it never to return.†

In the second place, if a deciduous forest is destroyed by lumbermen or swept by fire it presents a very different appearance for a time, but if left undisturbed it will regain its former appearance and flora, or very nearly so, as soon as the trees have time to grow up again. But if the cutting or burning is repeated every few years the ground will gradually become covered with herbs and short-lived shrubs, among which it is difficult for trees to regain a foothold.

(This tendency of vegetation to restore itself seems to be quite analogous to elasticity in physics. For example, if any solid sub-

* See Ann. N. Y. Acad. Sci. **17**: 117. 1906.

† See Mohr, Contr. U. S. Nat. Herb. **6**: 120. 1901.

stance of suitable material and form, such as a copper wire, is bent slightly and released immediately it will quickly resume its original shape; but if bent too much or kept bent too long it will remain so.)

In New England and southern New York, to which the following discussion will be chiefly confined, the modification of plant environments through human agency has come about chiefly in the following six ways.

A. Trees of a forest destroyed by fire, lumbering, etc., and allowed to grow up again without delay. Forest fires of course occurred more or less before man existed, but their frequency has been so greatly increased by civilization that they may now without serious error be regarded as one of its effects.

B. Trees removed and then kept down by repeated mowing, burning, grazing, or trampling, as in hay-fields, railroad rights-of-way, pastures, lawns, roads, and paths.

C. Original vegetation all or nearly all destroyed and soil disturbed, as in cultivated and abandoned fields, embankments, and excavations. Similar conditions are sometimes, though rarely, brought about in a natural way by landslides, etc.

D. Foreign matter added to the soil, as in gardens, barnyards, waste places, railroad yards, and ballast grounds.

E. The amount of water changed, as in drained marshes and swamps, irrigated lands, ditches, and artificial ponds.

F. Entirely new substrata provided, such as roofs, walls, wharves, pavements, and refuse and artificial substances of all kinds.

The plants which follow treatment *A* are practically all native in the adjacent undisturbed forests or elsewhere in the vicinity, and those of *E* are also usually native, within a few miles at least. After *B* and *C*, European weeds are numerous, if not in the majority. The plants of *D* are nearly all exotics, and those of *F* are mostly cellular cryptogams of very wide distribution.*

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* For the names of some of them see Meyen, Grundriss der Pflanzengeographie, 87–92. 1836 (or pages 73–78 of the English translation, 1846). The alleged new species of fungi which have been described in the last few years from such places as "a box where acetic acid had been spilled," and "among grasses where coal ashes had been lying," as well as the numerous native fungous parasites of exotic plants, are also to be classed here.

The plants of the various unnatural habitats created in the manners above indicated may also be classified as follows:

1. Species undoubtedly indigenous in our forests, which spring up quickly in clearings and to a lesser extent in other unnatural places, and tend to restore them to their original condition.

2. "Fireweeds," or species especially characteristic of recently burned woodlands, gradually disappearing with the process of reforestation. Some of them are herbs, some shrubs and some trees. If reforestation is prevented, as in case *B*, some of the fireweeds are apt to remain and behave like ordinary roadside or introduced weeds. There are probably hardly more than a score of typical fireweeds in the northeastern states, but very little is known as yet of their origin and history. Lists of such plants for various northeastern localities have been published as follows:

Dawson, Am. Jour. Sci. II. **4**: 164–166. 1847. (Nova Scotia.)

Thoreau, Maine Woods, appendix. (There are several editions, so it is hardly worth while to give date and page.)

Prentiss, Bull. Torrey Club **10**: 44. 1883. (Adirondacks.)

Chickering, Bot. Gaz. **9**: 193–194. 1884. (Maine.)

Sargent, Tenth Census U. S. **9**: 492, 497, 502–503, 510, 558. 1884.

Fernald, Trans. Mass. Hort. Soc. **1905**: 11. 1905.

Chittenden, U. S. Bureau Forestry Bull. **55**: 21, 37–38, 50–51, 67–70. 1905. (New Hampshire.)

3. Species native in naturally treeless or sparsely wooded dry areas in the same general regions, and therefore well adapted to such unnatural habitats as those under the second head. The naturally treeless areas of this part of the country, other than those of the seacoast and high mountains, are very imperfectly understood. The principal ones seem to be the "sand-plains" of the less elevated parts of New England, and the "Hempstead Plains" of Long Island, which resemble in aspect some of the western prairies. Existing botanical literature gives very little information about such places. Two lists of New England sand-plain plants were published in 1903; one by J. W. Blankinship (Rhodora **5**: 128, 129) for eastern Massachusetts, and one by W. E. Britton (Bull. Torrey Club **30**: 581–585) for southern Connecticut. Dr.

Blankinship's list is rather fragmentary, Dr. Britton's includes a number of introduced species, and neither is as sharply limited as it might have been. The flora of the Hempstead Plains, which is somewhat similar, has never been published, but it seems to comprise about 80 native species of vascular plants.

4. Species undoubtedly native in open woods, pine-barrens or prairies farther south and west, which have probably come into the northeastern states only since the clearing away of most of the forests has destroyed much of the humus and made the summers warmer. To this class probably belong a number of species of Compositae, Leguminosae, *Crataegus*, etc., but it would be difficult to specify any particular species.

5. Species which grew in Indian clearings before the white man came, so that it is now impossible to determine where they are really native. There is not much on record about these in the parts of our country which have been settled the longest. *Phytolacca decandra* is supposed to be one of them, and a few others of southern distribution are mentioned in Mohr's Plant Life of Alabama, page 54. Such plants are mostly to be looked for in the first three classes of unnatural habitats, and they cannot be very numerous.

6. Species not included in any of the five foregoing classes, supposed to be native in the eastern United States, but apparently confined to unnatural habitats, and behaving like introduced plants, from which they are to be distinguished in most cases only by documentary evidence. These will be discussed at length farther on.

7. Weeds naturalized from foreign countries, where most if not all of them have been accustomed to unnatural habitats for centuries. These occupy habitats of class *D* almost to the exclusion of natives, are very common in *C*, less so in *B*, rare in *A*, and are wanting in perfectly natural habitats. The number of weeds certainly known to have been introduced into this country is quite large, constituting at present in the northeastern states about 20 per cent. of the angiospermous flora.*

8. Exotic plants which grow spontaneously for a time, but are

* For an interesting discussion of some plants of this and the next class see Fernald's lecture on "Some recently introduced weeds" (Trans. Mass. Hort. Soc. 1905: 11–22. 1905).

not sufficiently adapted to our conditions to spread. These, often designated adventive or fugitive plants,* are confined chiefly to habitats *C* and *D*, especially the latter.

9. Cultivated plants, which are unable to compete with those in the other groups, and grow only where they are planted and protected by man, as in fields, gardens, hothouses, flower-pots, etc. In the northeastern states probably nine tenths of the species of this and the two preceding groups are of European origin.

It is with class 6, the native weeds, that we are chiefly concerned. A few lists of such plants for various parts of the eastern United States and neighboring territory have been published as follows:

NEW BRUNSWICK: Ganong, Bot. Gaz. **36**: 432, 435. 1903; **42**: 89–90, 98–99. 1906.

MAINE: Thoreau, Maine Woods (appendix).

VERMONT: Brainerd, Jones, & Eggleston, Fl. Vt. 94. 1900.

MASSACHUSETTS: Blankinship, Rhodora **5**: 128, 135. 1903.

PENNSYLVANIA: Harshberger, Bull. Torrey Club **31**: 152–155, 156–158. 1904.

MICHIGAN: Beal, 5th Rep. Mich. Acad. Sci. (Mich. Flora) 27. 1904; F. B. H. Brown, Bot. Gaz. **40**: 277. 1905; Transeau, Bot. Gaz. **40**: 435, 438, 440–441, 443–444, 446–447. 1905.

ILLINOIS: Brendel, Flora Peoriana 36. 1887.

VIRGINIA: Kearney, Contr. U. S. Nat. Herb. **5**: 407–409, 472. 1901.

TENNESSEE: Gattinger, Fl. Tenn. (ed. 2) 13–14. 1901.

GEORGIA: Harper, Bull. Torrey Club **27**: 327–328, 329, 421. 1900; **30**: 338. 1903; Ann. N. Y. Acad. Sci. **17**: 114–116. 1906.

ALABAMA: Mohr, Contr. U. S. Nat. Herb. **6**: 64 (near top), 65 (middle). 1901.

MISSISSIPPI and LOUISIANA: Lloyd & Tracy, Bull. Torrey Club **28**: 83. 1901.

It happens, however, that in all or nearly all of the lists just cited there is more or less admixture of exotics or of undisputed natives, or both. To illustrate therefore just what kind of plants I would call native weeds I offer the following examples, which I

* See in this connection Mohr, Contr. U. S. Nat. Herb. **6**: 53–56. 1901.

have observed in southern New England (mostly in Southbridge, Mass., and neighboring towns) and the western half of Long Island. Those to which interrogation points are prefixed may possibly belong to some of the eight other classes mentioned above, but they are mentioned to attract attention and invite discussion, by which their status may perhaps be settled.

? *Krigia virginica* (L.) Willd.
Lactuca canadensis L. (and perhaps others).
Achillea Millefolium L.
Bidens frondosa L. (and perhaps others).
Gnaphalium obtusifolium L.
Anaphalis margaritacea (L.) B. & H.
Erigeron ramosus (Walt.) B. S. P.
Leptilon canadense (L.) Britton.
Aster Novae-Angliae L.*
" *vimineus* Lam.
" *diffusus* Ait. (and several others).
Euthamia graminifolia (L.) Nutt.
" *caroliniana* (L.) Greene (and intermediate forms).
Solidago canadensis L.
" *nemoralis* Ait. (and some others).
Xanthium spp.
Ambrosia trifida L.
" *artemisiaefolia* L.
Lobelia inflata L.
Specularia perfoliata (L.) A. DC.
Sambucus canadensis L.†
Houstonia coerulea L.
? *Plantago major* L.
" *Rugelii* Decne.
Linaria canadensis (L.) Dumont.
Ilysanthes gratioloides (L.) Benth.
Mentha canadensis L.
? *Koellia virginiana* (L.) Britton.
Prunella vulgaris L.
Verbena urticaefolia L.
Convolvulus Sepium L.
Asclepias syriaca L.
? *Cornus candidissima* Marsh.
? *Ptilimnium capillaceum* (Michx.) Raf.
Kneiffia pumila (L.) Spach.
Oenothera biennis L. (and others).
Isnardia palustris L.
Viola (many species, especially the acaulescent blue-flowered ones).
Hypericum maculatum Walt.
" *mutilum* L.
Sarothra gentianoides L.
? *Celastrus scandens* L.
? *Rhus typhina* L.
Euphorbia maculata L.
" *Preslii* Guss.
Acalypha virginica L.
" *gracilens* Gray.
? *Polygala verticillata* L.
Oxalis (the yellow-flowered ones).
? *Lespedeza* (several species).
Cassia marylandica L.
Chamaecrista spp.
Crataegus (many species).
Agrimonia spp.
Potentilla simplex Michx. (and others).
? *Fragaria virginiana* Duchesne.
? " *americana* (Porter) Britton.
Rubus spp. (numerous blackberries).
Lepidium virginicum L.
Cardamine hirsuta L.
Ranunculus abortivus L.
? *Anemone cylindrica* Gray.
Silene antirrhina L.
? *Polygonum aviculare* L.
" *erectum* L.
" *pennsylvanicum* L.
? " *Hydropiper* L.
? " *sagittatum* L.
" *scandens* L.
? *Rumex Acetosella* L.
Urtica gracilis Ait.
? *Salix discolor* Muhl. (and others).

* See Torreya 7: 173. 1907.

† See Gray, Am. Nat. 1: 493–44. 1867; 2: 38–39. 1868; Allison, Auk 21: 473. 1904; Harper, Ann. N. Y. Acad. Sci. 17: 154. 1906.

Sisyrinchium (several species).
? *Smilax rotundifolia* L.
? *Juncus effusus* L.
" *marginatus* Rostk.
? " *bufonius* L.
" *tenuis* Willd. (and probably others).
? *Spirodela polyrrhiza* (L.) Schleid.
? *Carex lurida* Wahl.
? " *pallescens* L.
" *festucacea* Willd.
? " *Muhlenbergii* Schk. (and probably a few others).
? *Fimbristylis autumnalis* (L.) R. & S.
Eleocharis obtusa (Willd.) Schult. (and perhaps others).
? *Cyperus filiculmis* Vahl.
Eragrostis pectinacea (Michx.) Steud.
Eragrostis Purshii Schrad.
Agrostis hiemalis (Walt.) B. S. P.
? *Sporobolus vaginaeflorus* (Torr.) Vasey.
? *Aristida gracilis* Ell.
" *dichotoma* Michx.
Muhlenbergia mexicana (L.) Trin. (and perhaps others).
Chaetochloa spp.
Panicum (several species).
? *Syntherisma sanguinale* (L.) Nash.
" *filiforme* (L.) Nash.
Paspalum setaceum Michx. (and perhaps others).
? *Andropogon* spp.
? *Juniperus communis canadensis* Loud.*
? *Equisetum arvense* L.
? *Botrychium obliquum* Muhl. (and some allied forms).

In the southeastern states there are many other species in the same category, and a complete list would probably include something like 10 per cent. of the species of flowering plants supposed to be indigenous in the eastern United States. How to treat these plants in phytogeographical works is therefore an important question.

If they are indigenous, but now confined to unnatural habitats, the first inquiry that suggests itself is: where did they grow a few hundred years ago, when their present habitats did not exist? Unfortunately, New England and New York were pretty well settled before botany became a science, and by the time American botanists began to study vegetation, rather than plants merely, there were nearly as many roads, pastures, clearings, etc., as there are today, so early botanical literature throws little light on the subject. Several explanations have been suggested, and each may account for some species, but none will satisfactorily cover all cases.

In the first place, it seems to be a common belief among those northeastern botanists who have given any thought to the matter that in prehistoric times all our native weeds occupied natural openings in the forests, which have now been completely obliter-

* See U. S. Forestry Bull. **55**: *pl. 5. f. 1.* 1905. This is a shrubby form of *Juniperus communis*, which has gone by several different names in recent years.

ated, and that the multiplication of clearings has given these plants opportunity to become widely disseminated. The chief objection to this theory is that the only naturally treeless areas in New England and New York (as far as can be ascertained from botanical literature) seem to be bodies of water, marshes, meadows, sand-plains, dunes, high cliffs, and mountain summits;* and few if any of the plants in question belong to such habitats. But even granting that there could have been natural openings of a kind which no longer exist in their original form, if all our native weeds inhabited them their flora must have been far richer in proportion to area than that of any other habitat known in the eastern United States today, which is incredible.

It would seem therefore that the only possible explanation for most of these species is that they have originated in some manner or other in the last few centuries, as I ventured to suggest in the case of some Georgia weeds not long ago.† Some of the species in question may even have originated within the last fifty years or so, for it is scarcely conceivable that all the new species of *Aster*, *Viola*, *Crataegus*, *Rubus*, etc., which have been described from unnatural habitats in recent years could have been overlooked by the botanists of a century ago, if the plants existed then. Our herbaria do not help us much in this particular, for specimens more than fifty years old are very rare, and almost never cited in the descriptions of new species.

There is more than one way of accounting for the modern origin of some of these species. Dr. Brainerd‡ has sagely suggested that the great multiplication of species of *Viola*, *Crataegus*, *Panicum*, etc., is chiefly due to increased opportunities for hybridization; which seems to be a modification of Kerner's§ theory that

* According to Thoreau the only openings in the Maine woods, about the middle of the 19th century, were rivers and lakes, burns and clearings, mountain summits, and perhaps a few meadows. The few plants of this class mentioned by him grew in burns and clearings. There are some evidences of about two square miles of dry land naturally treeless among the Adirondacks in Hamilton Co., N. Y., 1,855 feet above sea-level (see Field & Stream 12: 490. Oct. 1907, and the West Canada Lakes topographic sheet of the U. S. Geological Survey), but there seems to be nothing on record about its flora.

† Ann. N. Y. Acad. Sci. 17: 116. 1906.

‡ Rhodora 8: 10. 1906.

§ Pflanzenleben 2: 582–588. 1891. (English translation, "Natural History of Plants" 2: 595–600.)

all species now living originated by hybridization. But although the occurrence of natural hybrids has been demonstrated in some of the genera listed and strongly suspected in others,* hybridization would hardly increase the number of species ten-fold in *Crataegus* for instance in so short a time. And some of the genera are still so small that the possible hybrids in them must be very limited in number.

For the large number of cases still unexplained we shall probably have to fall back on the mutation theory, as being the only other one which explains the sudden origin of new forms. Only a few well-authenticated cases of mutation have hitherto been detected, and there is still considerable diversity of opinion as to the cause of the phenomenon. De Vries seemed to think that each species passes through periods of mutation at long intervals, and that his epoch-making discovery was largely due to the fact that he happened to have a mutating species of *Oenothera* under careful observation just at the critical period. MacDougal has succeeded in inducing mutation, or something that looks very much like it, in the same genus by artificial means, and from this he infers that the cause of mutation may at least in some cases be external to the plant.† Blaringhem seeks this external cause in mechanical injuries (such as cutting the stem) at the time of maximum vegetative activity.‡ This seems quite plausible in view of the fact that de Vries's Oenotheras are said to have grown in a field which was cut over sometimes, and most of our meadow and roadside plants get similar treatment every year.

Although the writer does not claim to be familiar with the physiological aspects of the mutation theory or theories, it seems to him perfectly reasonable to suppose that change of environment alone may be a sufficient cause, or stimulus, of mutation, or at least of rapid evolution. Indeed it is more than likely that all evolutionary changes (other than hybridization) in the vegetable kingdom have been preceded by changes of environment. Geological history confirms this view, for one of its most prominent features is the great difference in the organisms of successive periods, the

* See MacDougal, Bot. Gaz. **43**: 57. 1907.

† See Yearbook, Carnegie Inst. **5**: 129. 1907.

‡ Mutation et Traumatismes. Paris, 1907.

intervals between which were marked by great and rapid changes on the earth's surface.* Another circumstance which points to the same conclusion is that closely related species do not usually occupy the same habitat, as every experienced field worker knows.†

An extremely significant point is that no case of mutation seems to have hitherto been detected in any species whose environment has not been disturbed by civilization. All plants now being studied which give promise of mutation phenomena are either weeds or cultivated plants. Probably no species can come into close contact with civilization for any length of time without being more or less modified sooner or later. As Dr. H. J. Webber said about ten years ago:‡ "No instance is known of a plant being long under cultivation and not furnishing several varieties."

Most of our introduced weeds, or rather their ancestors, doubtless experienced the same change of environment in the Old World centuries ago that our native weeds have in more recent times; and the first step in the economic development of every one of our cultivated plants which is no longer known in the wild state must have been the creation of a new environment for it, purposely or otherwise.

Against the comparatively sudden origination of new forms under the pressure of changed environment might be urged the often cited experiments of European botanists who have transplanted alpine plants to lowlands and vice versa without producing any permanent or inheritable variations thereby. The answer to this is that probably such experiments have not been continued long enough. For all we know, a century or more of exposure to different conditions may be necessary in most cases to start mutation, or "break the type," as Dr. Webber puts it. Some species are doubtless more susceptible than others,§ and those experi-

* See the papers by Dall, King, LeConte, and White, cited below.

† See in this connection Abrams, Science II. 22: 836–838. 22 D 1905.

‡ Yearbook U. S. Dept. Agr. 1896: 103. 1897.

§ This might be inferred from the fact that in the foregoing list such large families as Gentianaceae, Ericaceae, Umbelliferae, Orchidaceae, and Liliaceae are not represented at all, and some others very sparingly in proportion to their numbers. Woody plants must change more slowly than herbs, and this is perhaps one reason why the species of *Crataegus* and *Rubus* have not been greatly multiplied by systematists until lately.

mented with might have happened to be among the least susceptible.

Another important point to be considered is that if our native weeds have sprung into existence in modern times, they should all be closely related to species that are undoubtedly native. This indeed seems to be true in most cases; and the rest deserve further investigation. It seems very likely that in this class of plants we may have many examples of polygenesis, i. e., of a single species originating independently at several or many different places; a phenomenon whose possibility was denied by Darwin and some of his successors.*

The suggestion that mutation may be induced by civilization is not exactly a new one, for premonitions of it have appeared in one form or another in the writings of botanists and zoölogists several times in the last few years,† and one occasionally hears interesting rumors about it from persons who have not ventured to put their ideas on the subject into print; but it does not seem to have attracted much attention yet, especially among systematists, many of whom are going right on describing "new species" from unnatural habitats without inquiring into their history or making any distinction between them and species which are truly indigenous to our primeval forests.‡

To admit the modern origin of native weeds would simplify a number of vexed problems, and put an end to many of the fruitless discussions of the indigeneity of certain species which have been going on in some of our botanical journals.§ It would also partly explain the greater richness of the herbaceous flora of Great

* See Clements, Bot. Surv. Neb. 7: 68–77. 1904; Research methods in ecology 230–232. 1905.

† See Dunn, Jour. Bot. 40: 359. 1902; Spalding, Plant World 10: 140. Je 1907; Cockerell, Science II. 26: 72–73. 19 Jl 1907.

‡ As recently as August, 1907, a prominent systematist has published the following statement (Jour. Bot. 45: 290): "The origin of these many forms [of *Crataegus* in North America] I cannot pretend to account for. The theory that they are hybrids of recent origin, however, can hardly be accepted."

§ In one magazine alone, the Journal of Botany, I have noticed discussions of this kind (mostly relating to British plants) at the following places in the last twelve volumes: 34: 201–204. 1896; 37: 356–358. 1899; 40: 356. 1902; 41: 141–142, 150–154, 285, 289–290. 1903; 43: 89–94. 1905; 44: 138–142, 207–213, 390. 1906.

Britain, New England, etc., as compared with more newly and thinly settled regions of equal area and diversity. For in these old countries few if any native species have yet been completely exterminated, while the flora has been greatly augmented by the species which seem to have been produced to meet the new conditions of environment, to say nothing of introduced species, which must have originated in a similar manner somewhere else.

Furthermore, it will be noticed that the list given contains the names of the genera which in the past decade or two have furnished the most employment for species-makers in this part of the world; such as *Achillea*, *Bidens*, *Aster*, *Viola*, *Euphorbia*, *Oxalis*, *Lespedeza*, *Chamaecrista*, *Rubus*, *Agrimonia*, *Polygonum*, *Salix*, *Sisyrinchium*, *Smilax*, *Juncus*, and *Panicum*. By analogy we may expect some of the other genera to prove equally polymorphous before long. European botanists have long been having similar troubles with *Hieracium*, *Crepis*, *Centaurea*, *Cirsium*, *Campanula*, *Galium*, *Orobanche*, *Euphrasia*, *Euphorbia*, *Astragalus*, *Trifolium*, *Rubus*,* *Rosa*, *Potentilla*, *Saxifraga*, *Ranunculus*, *Fumaria*, *Erysimum*, *Silene*, *Dianthus*, *Crocus*, *Carex*,† *Festuca*, *Poa*, *Avena*, and numerous other genera, and doubtless for similar reasons.

Such plants as these, however interesting they may be to the horticulturist, economic botanist, evolutionist, and laboratory worker, have no place in a description of the natural or primeval vegetation of the country, and their study can throw but little light on the pre-historic development of the native flora, which is one of the chief concerns of the phytogeographer. Their number will probably continue to increase as long as the population of the earth increases, and when they are described it would seem desirable to keep them by themselves, like cultivated plants, instead of cumbering the pages of our manuals with them, to the confusion and despair of the average botanist. In the present state of our knowledge it may seem impossible to make a sharp distinction between native weeds and members of the original flora; but authors

* The perplexities of this genus in Europe are so great that English botanists have invented a special name, "batologists," for those who study it most.

† *Carex*, although one of our largest genera, has not furnished as many "new species" in the Eastern United States in the last fifty years as several formerly much smaller genera have. May this not be correlated with the fact that very few of our *Carices* are found in unnatural habitats?

of new species hereafter might at least do a great service to their successors by describing the habitats as explicitly and systematically as possible in every case. Habitat has been almost universally regarded by systematists as a matter of minor importance, or ignored entirely; but inasmuch as it represents the combined expression or resultant of geological history and all the properties and adaptations of the species, its importance cannot be overestimated.*

The following works (most of which have not been mentioned in the foregoing pages), together with the references given in some of them, bear more or less directly on the subject under discussion.†

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Dawson, J. W. On the destruction and partial reproduction of forests in British North America. Am. Jour. Sci. II. **4**: 161–170. S 1847. (Deals especially with succession of vegetation in burned areas.)

Dunn, S. T. Origin of the deadnettles in Britain. Jour. Bot. **40**: 356–360. O 1902. Discussed by E. S. Marshall in the next number (390–391).

Dunn, S. T. A preliminary list of the alien flora of Britain. 1–30. 1903. (Not seen.) Reviewed in Jour. Bot. **41**: 141–142. Ap 1903; and discussed by H. J. Riddelsdell in same, **43**: 89–94. Mr 1905.

Dunn, S. T. Alien flora of Britain. i–xiv + 1–208. 1906. (Not seen.) Reviewed by H. J. Riddelsdell in Jour. Bot. **44**: 138–142. Ap 1906; and discussed by E. S. Marshall in same, 207–213. Je 1906.

*In this connection pages 10–11 of Dr. B. L. Robinson's address on "The problems of ecology" (read before the "Congress of Arts and Science" in St. Louis in 1904, and reprinted in 1906 from the fifth volume of the proceedings of the Congress) are well worth reading.

†Some of these I have seen only in the library of the Staten Island Association of Arts and Sciences. For the privilege of examining most of the remainder I am indebted to the New York Botanical Garden.

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MacDougal, D. T. Heredity and environic forces. Science II. **27**: 121–128. 24 Ja 1908. (Vice-presidential address, Section G, A. A. A. S.)

Malinvaud, Ernest. The species and hybrids of *Mentha*. (Translated from the French.) Jour. Bot. **38**: 171–174. Ap 1900. (See also Plant World **10**: 139. Je 1907.)

Rothrock, J. T. A nascent variety of *Brunella vulgaris* L. Contr. Bot. Lab. Univ. Pa. **1**: 64–65. 1892. (See also Amer. Bot. **13**: 21. S 1907.)

Thoreau, H. D. The Maine woods. (Originally published in 1864. My copy is an 18mo, with 359 pages and an introduction, published by T. Y. Crowell & Co. of New York in 1906. The list of plants occupies pages 329–348.)

Webber, H. J. Influence of environment in the origination of plant varieties. Yearbook U. S. Dept. Agr. **1896**: 89–106. *f. 16–23.* 1897. (A very interesting and valuable paper, which does not seem to have received the recognition it deserves, though the author is well known.)

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Studies in North American Peronosporales—III. New or noteworthy species*

Guy West Wilson

Albugo Trianthemae sp. nov.

Soris hypophyllis, rotundis vel irregularibus, rarius confluentibus, immersis, promentibusque, subflavidis, 1–10 mm. latis, conidiophoris cylindraceis, circa 10 × 60 μ; conidiis subflavidis, breviter cylindraceis, circa 8–10 μ × 8–10 μ, terminalibus majoribus, circa 9–11 μ × 12–14 μ, membrana hyalina, ad medium annulo cincta; oosporis in foliis hospitis, globosis, 60–80 μ diametro, episporis brunneis, regulariter vel irregulariter reticulatis, areolis circa 4 μ latis.

Sori hypophyllous, rounded or irregular in outline, rarely confluent, rather deep-seated, prominent, yellowish, 1–10 mm.; conidiophores cylindric, about 10 × 60 μ; conidia short-cylindric, 8–10 μ × 8–10 μ, the terminal larger, 9–11 μ × 12–14 μ, membrane hyaline, with an equatorial thickening, contents light yellow, oöspores produced in the leaves of the host with the conidia, globular, 60–80 μ, averaging about 70 μ, epispore dark brown, rather closely and shallowly reticulate, areolae regular or irregular, about 4 μ.

Type in herb. Wilson, and duplicates of the same collection in herb. Underwood and the herbarium of the New York Botanical Garden. Collected by E. O. Wooton near Las Cruces, New Mexico, on *Trianthema Portulacastrum* L.

This species stands between *Albugo occidentalis* and *A. platensis*, being distinguished from the former by its larger conidia, which are lighter in color and dissimilar in size, and by its larger and darker oöspore, which is less regularly and more deeply reticulate; and from the latter by its cylindric conidia with the membrane similarly colored throughout, and by its larger and less deeply reticulate oöspore. The conidia are also quite similar to those of *A. Tragopogonis* but the oöspores are not tuberculate. The host suggests an affinity with *A. Portulacae*, but the annulate, dissimilar conidia and the absence of the tubercles in the areolae of the oöspore preclude such a relationship.

* Presented before Section G, A. A. A. S., at Chicago, Dec. 31, 1907, as "New or noteworthy Peronosporales."

Albugo Froelichiae sp. nov.

Albugo Cladothricis G. W. Wilson, Science II. **27**: 207. 1908. (Hyponym).

Soris hypophyllis vel in caulibus, superficialibus prominentibusque, albis vel subflavidis, subrotundis vel irregularibus, 1–3 mm. latis; conidiophoris subfusiformibus, elongatis, 12–18 μ × 70–85 μ; conidiis subflavidis, breviter ellipticis, terminalibus minoribus, globosis, 10–18 μ × 12–20 μ, membrana subflavida, ad medium annulo cincta; oosporis in foliis hospitis, brunneis, globosis, 45–80 μ; episporis irregulariter vel regulariter reticulatis, areolis circa 7 μ latis.

Sori hypophyllous or caulicolous, prominent, superficial, white or light yellowish, rounded or irregular in outline, 1–3 mm.; conidiophores long, somewhat fusiform, 12–18 μ × 70–85 μ; conidia uniformly light yellow throughout, short-elliptic, 10–16 μ × 12–18 μ, the terminal smaller, globose, the membrane with an equatorial thickening; oöspores produced in the leaves of the host, globose, 45–80 μ, averaging 70 μ; epispore dark brown, rather opaque, coarsely and irregularly, or even regularly reticulate, areolae about 7 μ.

Type in herb. Wilson and duplicate in the herbarium of the New York Botanical Garden, collected by W. H. Long, at Denton, Texas, on *Froelichia gracilis* Moq.

ON AMARANTHACEAE:

Cladothrix lanuginosa (Moq.) Nutt., Kansas, *Hitchcock 431;* New Mexico, *Wooton;* Mexico, *Berlandier.*

Froelichia campestris Small, Texas, * *Long* [Fungi Columb. *2407*, "on *F. floridiana* (Moq.) Nutt."].

Froelichia gracilis Moq., Texas, * *Long* (type).

DISTRIBUTION: Kansas to Mexico.

The present species is very closely related to *A. Bliti* and *A. platensis*, but is distinguishable from the former by its yellowish sori and its yellow conidia, while it is easily separated from the latter by its conidia, which are brighter yellow, and never show the dark ring of that species. The conidia also separate it from the preceding species, to which it is closely related. The conidiophores are unique within the genus for their fusiform outline. The oöspores are very similar to those of *A. Bliti* but are larger in size.

PHYTOPHTHORA THALICTRI Wilson & Davis

Material of this species collected by Dr. Davis later in the season than the type collection indicated that the species is rather well distributed over southeastern Wisconsin. Although a careful search was made in New York in the early summer and in Indiana in the late summer, the species was not found in either locality. Dr. Davis observed the germination of the conidia, which behave in the typical manner for the genus.

PERONOSPORA CYPARISSIAE de Bary

This species is reported by T. A. Williams from South Dakota on *Euphorbia glyptosperma* Engelm. and *E. maculata* L.* An examination of this material shows the species in question to be *Peronospora Euphorbiae* Fuckel, the only species so far detected on North American Euphorbiaceae. The two fungi in question infest widely separated sections of the old genus *Euphorbia*.

PERONOSPORA RUMICIS Corda

The species has been recorded from North America on *Polygonum aviculare* L., *P. dumetorum* L., and *P. scandens* L. European mycologists recognize two species of *Peronospora* on Polygonaceae, *P. Rumicis* Corda on *Rumex* spp. and *P. Polygoni* Thümen on *Polygonum* spp. The two fungi are separated by differences of both conidia and conidiophores. *P. Rumicis* has conidiophores 3–6 times branched, with very short ultimate branchlets (2–4 μ long) and broadly ellipsoid conidia (26–33 μ × 16–23 μ), while *P. Polygoni* has conidiophores more lax, 5–7 times branched, the ultimate branchlets long (6–12 μ) and often curved, and elongate conidia (30–40 μ × 15–20 μ). The latter species is rather widely distributed in the northern United States, while the former, so far as my own observations go, has not been substantiated by authentic material from our region, nor do any of the recorded hosts indicate its presence in North America.

PERONOSPORA ARBORESCENS (Berk.) de Bary

In his report upon a collection of western Fungi Hume† records *Peronospora Corydalis* de Bary on *Argemone platyceras*

* Bull. Torrey Club **19**: 82. 1891.

† Proc. Davenport Acad. Sci. **7**: 254. 1899.

Coulter from Colorado. The close relationship between this and the usually recognized hosts of *P. Corydalis* gave the determination an air of probability which might not have been questioned were it not for the fact that another species, *P. arborescens*, is known in Europe and Asia on various species of *Papaver*. A careful comparison of the material in question with authentic European material of both the species in question shows that the American material belongs to *P. arborescens*, a species not heretofore recorded for North America.

PERONOSPORA FLOERKEAE Kellerman

This species has so far been recorded only from central Ohio and central Indiana. About the same time Dr. Kellerman collected the type material Mr. H. S. Jackson of the Delaware Experiment Station collected it in the vicinity of Newark, Delaware, and Mr. Holway collected it on the Wisconsin side of the Mississippi opposite some Minnesota point. From these new records it appears that the fungus and host are coextensive in range.

PERONOSPORA NICOTIANAE Speg.

This species was originally described by Spegazzini from Buenos Aires on *Nicotiana longiflora* * and later recorded by him on various other species of the same genus from this general region. From Buenos Aires there has been introduced into California, Texas and northern Mexico *Nicotiana glauca*, upon which in 1885 Dr. Farlow collected a *Peronospora* in California. This material was determined and distributed as *P. Hyoscyami* de Bary and records of its occurrence published in this country and copied abroad.† The European species of *Hyoscyamus* appear to harbor two species of *Peronospora*, *P. Hyoscyami* and *P. dubia*, the first of which bears a superficial resemblance to our species, while the second would never be confused with it. Both, however, belong to Berlese's section *Intermediae*, while our species belongs to the *Divaricatae*. Evidently, then, the European and American species are distinct. A comparison of our material with the de-

* Rev. Argent. Hist. Nat. 1: 36. 1 F 1891.

† Bot. Gaz. 10: 246. 1885. Gardeners' Chron. II. 9: 211. 1891.

scription of Spegazzini's species shows a close conformity thereto and leaves no doubt as to their identity, although no South American material is at hand for comparison. Judging from the origin of the host, it is not improbable that both host and fungus were introduced into the Southwest at the same time, although this is not one of the species recorded by Spegazzini as a host of *Peronospora Nicotianae*.

Inasmuch as the description of the species is rather inaccessible it is not unfitting to append a brief characterization:

Hypophyllous, forming brownish discolorations on the leaves; conidiophores erect, 250–500 μ × 10–12 μ, 6 or 7 times dichotomously branched, ultimate branchlets 15–18 μ × 2–3 μ, divaricate, acute; conidia ellipsoid or ovoid, 18–20 μ × 9–11 μ, very light violet; oögones globose, angled, hyaline, 80–100 μ; oöspores 50–80 μ, globose; epispore subopaque, closely reticulate, the areolae slightly elongate.

NEW YORK BOTANICAL GARDEN.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Arthur, J. C. A search for rusts in Colorado. Plant World **11**: 69–77. Ap 1908.

Arthur, J. C. The physiologic aspect of the species question. Am. Nat. **42**: 243–248. 18 My 1908

Benedict, R. C. Studies in the *Ophioglossaceae* — II. A descriptive key to *Botrychium* in North America: group of *B. lanceolatum*. Torreya **8**: 100–103. 19 My 1908.

Berry, E. W. Some Araucarian remains from the Atlantic coastal plain. Bull. Torrey Club **32**: 249–259. *pl. 11–16. f. 1, 2.* 29 My 1908.

Bessey, C. E. The taxonomic aspect of the species question. Am. Nat. **42**: 218–224. 18 My 1908.

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Britton, N. L. North American trees. i–x + 1–894. *f. 1–781*. New York. [9 My] 1908.

With the assistance of **J. A. Shafer.** Includes new species in *Juniperus, Populus*

(2), *Salix*, *Amelanchier*, *Acacia*, *Acer* (2), *Bumelia*, and *Fraxinus* (3); *Neostyphonia* Shafer, nom. nov. for *Styphonia* Nuttall; and *Canotiaceae* Britton fam. nov.

Brown, A. The Elgin Botanic Garden: its later history and relation to Columbia College, the New Hampshire Grants, and the treaty with Vermont in 1790. i–iv + 1–57. Lancaster, Pa. 1908.
Reprinted in advance from Bull. N. Y. Bot. Gard. **15**: 319–372.

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Clements, F. E. An ecologic view of the species conception. Am. Nat. **42**: 253–264. 18 My 1908.

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DeCandolle, C. *Begoniaceae* novae. Bull. Herb. Boiss. II. **8**: 309–328. *f. 1, 2.* 2 My 1908.
Includes new species in *Begonia* (20), and in *Semibegoniella*, gen. nov.

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Includes *C. Grayana* sp. nov. and *C. rotundifolia Bicknellii* var. nov.

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[Gibson, H. H.] American forest trees — 75. *Picea canadensis* Mill. Hardwood Record **26**[3]: 16, 17. 25 My 1908. [Illust.]

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